



*Mobility and Firepower  
for America's Army*



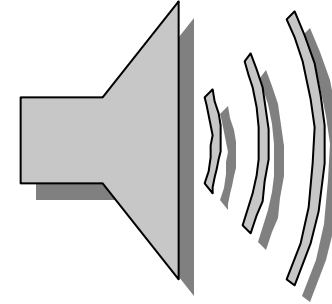
# *Directed Energy Assessment*

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# Acoustics Primer



How does acoustics work?

- Acoustic energy/power is generated by compressing a medium (in this case air) to create a pressure wave
- Acoustics are similar to mm/microwaves in many areas



# Advantages of Acoustics

- Can be directional, depending upon frequency
- Naturally provides area coverage, and hence area denial
- Can provide tunable target effects
  - Anti-personnel/anti-materiel
- Weather conditions
  - High relative humidity improves performance – not required
- Countermeasures
  - Non-aural target effects have few if any countermeasures
- Non-polluting



# Disadvantages of Acoustics

- Frequency
  - High frequency
    - Increased atmospheric attenuation
  - Low frequency
    - Reduced directionality to omni-directional
      - Potential for increased fratricide
    - More energy/power from source which increases system weight/volume and logistics burden
- Effects data – mostly anecdotal
  - On-going efforts to gather data





# Types of Sound Generation Sources

- **Piezo - Electric**

- *High Performance Speakers & Ceramics*
- *Smallest Volume Package*
- *Promising, Additional Work Needed*
- *Shortest Range against Single/Few Targets*



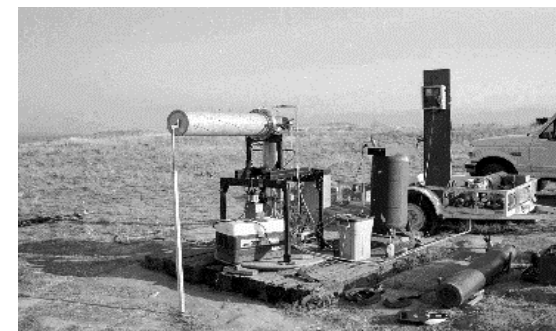
- **Compressed Air Driven**

- *Sirens*
- *Cover Larger Area*
- *Brassboard Available*
- *Can Be Made Directional*



- **Combustion Driven**

- *Pulser, Siren, Flame Tube Vortex, Detonation Tubes*
- *Cover Larger Area*
- *Brassboard Available*
- *Can Be Made Directional*

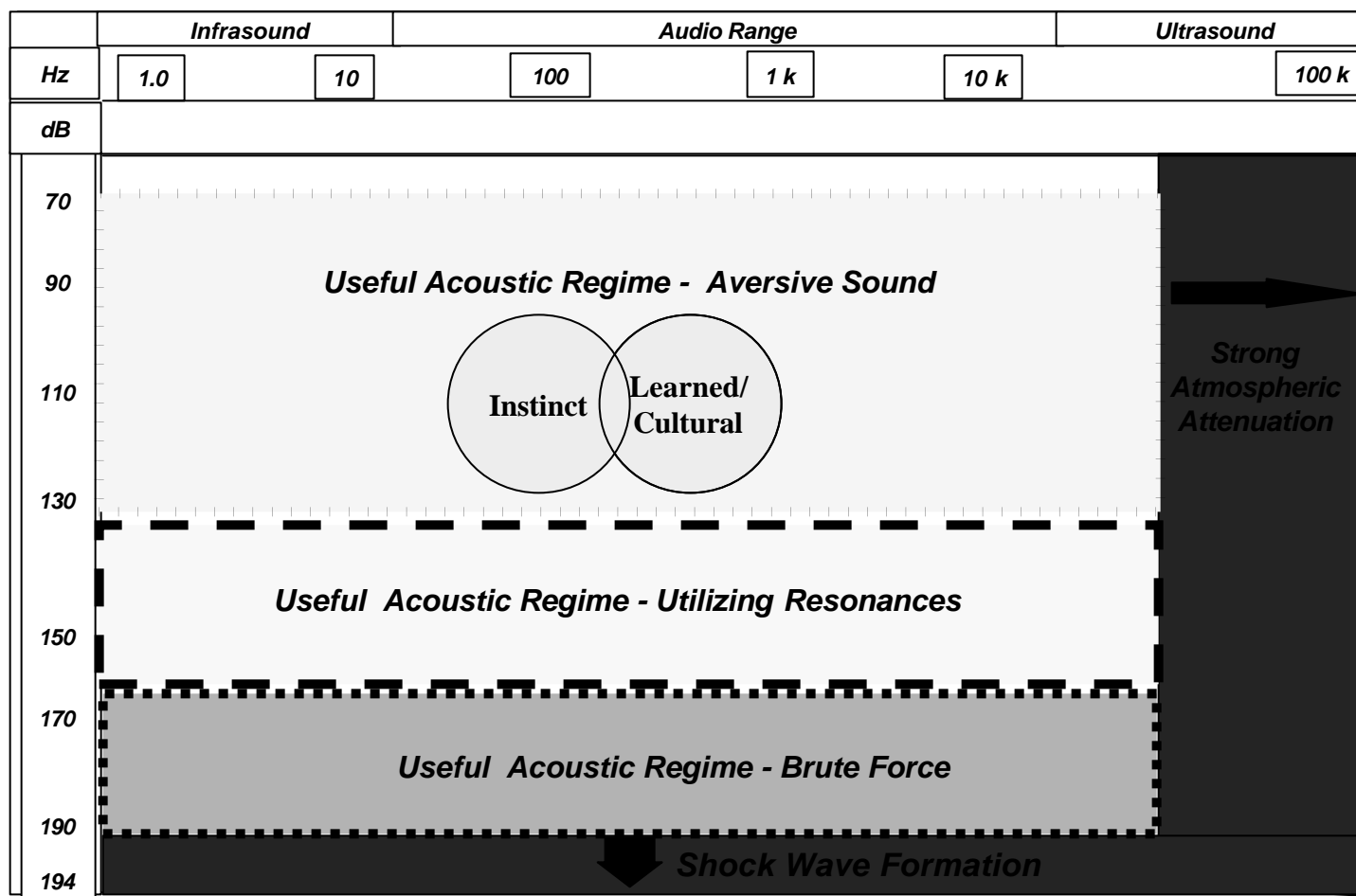






# Useful Acoustic Regime

Intensity  
(dB)



**Omnidirectional**

**Directional**



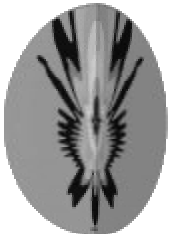
# Aversive Audible Acoustic Device (A3D)



**Concept of Operations:** Develop an acoustic device that can be used for crowd control, clearing facilities, or incapacitating individuals. Weaponization options include an acoustic cannon, UAV/UGV delivery, or artillery munitions.

**Potential Applications:**

- Area Denial, Clear Facilities, Crowd Control, Facilities Protection.



**Based on the Gayl Blaster**

- Highly directional beam of acoustic energy
- Initial Signal: 3400-Hz Center Frequency
  - Adjustable Frequency, Phase
  - SPL ~ 118dB<sub>RMS</sub> @ 1-m



**Potential for increased effectiveness by broadcasting Aversive Sound.**





# A3D System Characteristics

- Effects
  - Audible range
  - Non-injurious effects
  - Behavior modification
  - Effects not intensity based
- Countermeasures
  - Hearing protection not effective

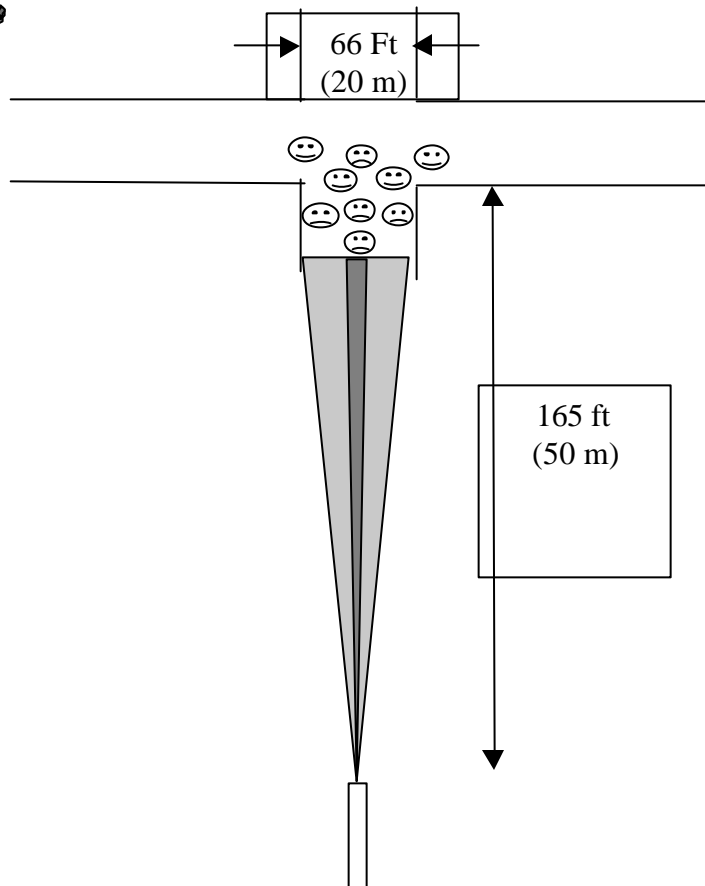


# Operational Capabilities

- Increased comfort zone
  - Between friendly forces/equipment and belligerents
    - Potential to contain/reduce escalation factor
- Enhances maneuverability
- Provides force protection



# Application for Initial Device



Mode 1:

Commander/Individual Soldier Communicates to Combatants, then bathe the entire area with low/mid intensity aversive sound



Mode 2:

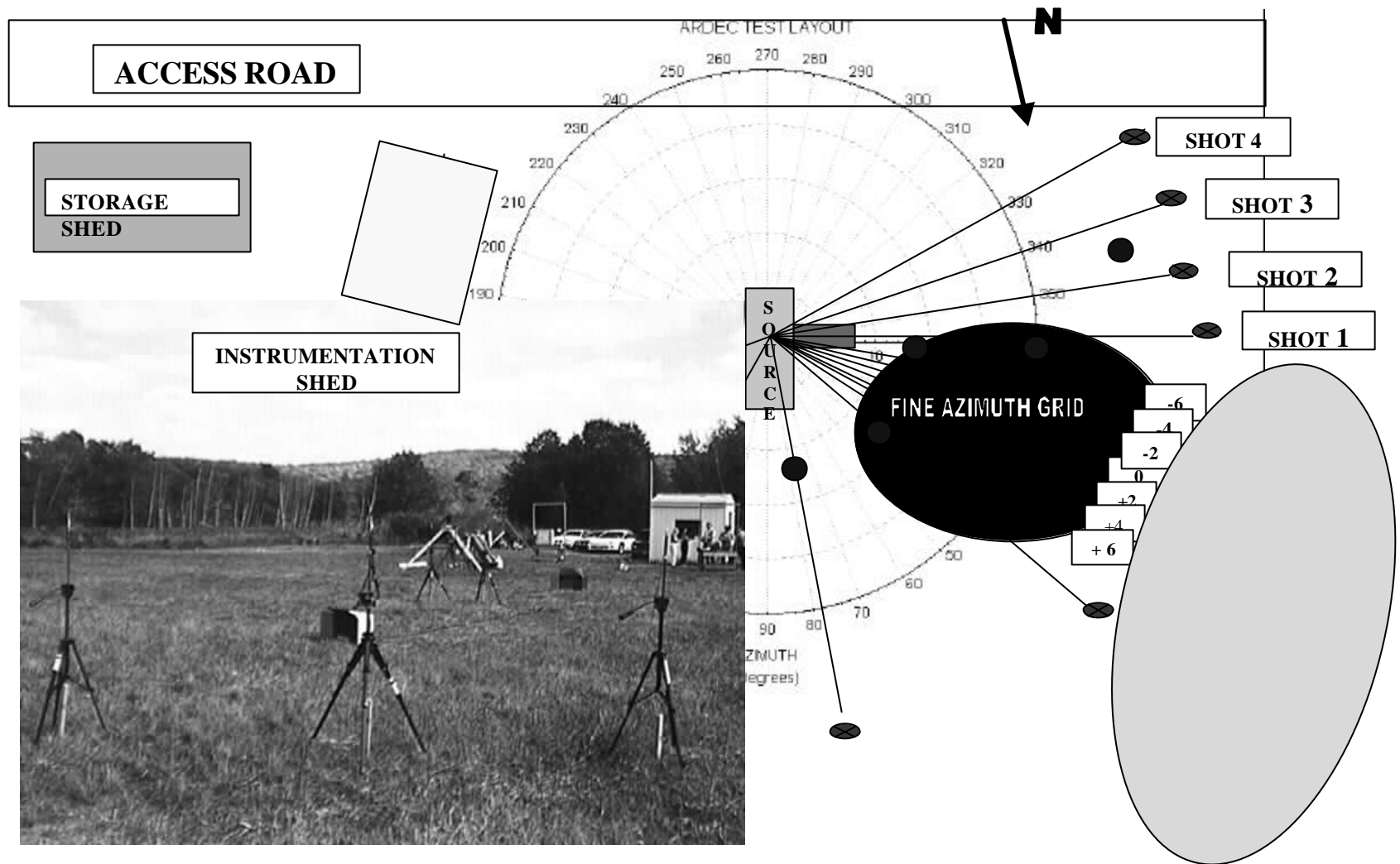
Commander/Individual Soldier Communicates to Individual Combatant(s). If non-responsive bathe individual combatants with high intensity aversive sound



## Bottom Line Payoff To Warfighter/User

- Provides the User with capabilities which more closely match warfighting requirements
  - Area denial
  - Military operation other than war (MOOT)
  - Military operation in built-up areas (MOBA)
  - Military Operations in Urban Terrain (MOUT)
  - Facility protection
  - Law enforcement (prisons, crowd control)





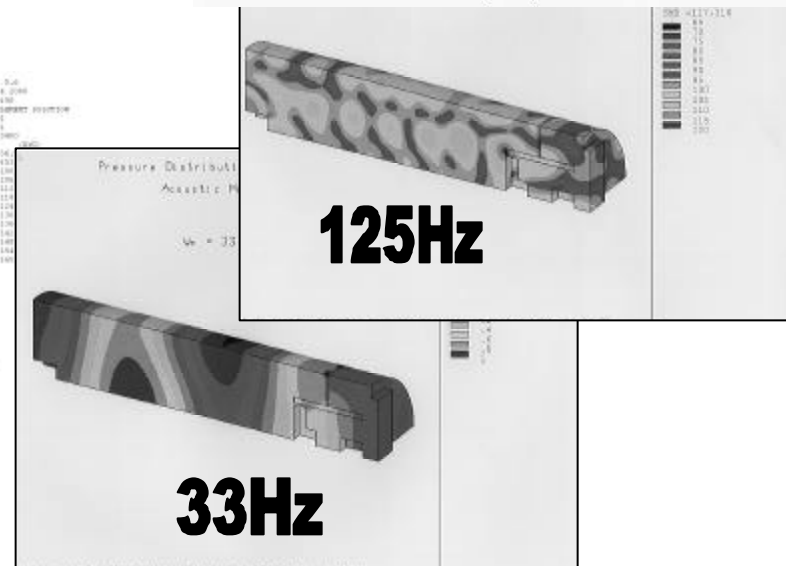
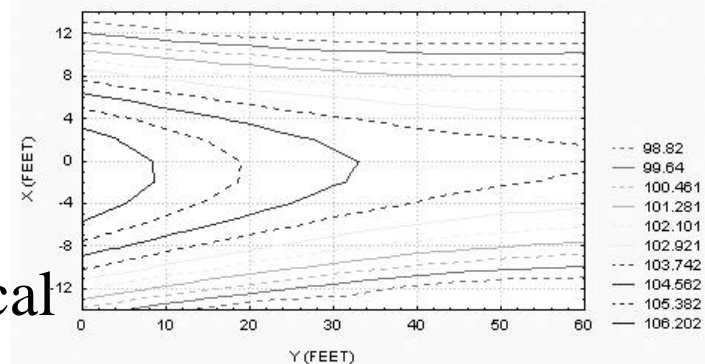


# ANSYS Modeling

Extensive use of simulation and modeling

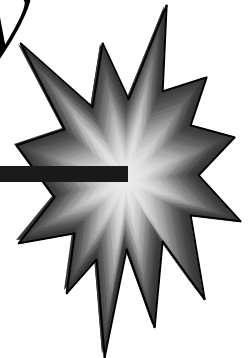
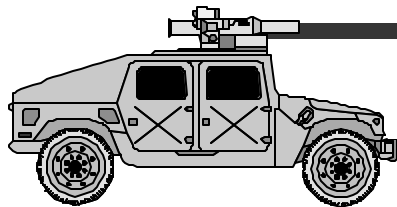
- Predict emissions of acoustic sources
- Response of enclosures
- Validated through experimentation
- Future modeling of impact on biological systems

BUNKER 1201 WHITE NOISE CONTOUR  
AT Z=3 FEET  
SPL (dBRMS)





# *Laser Technology*





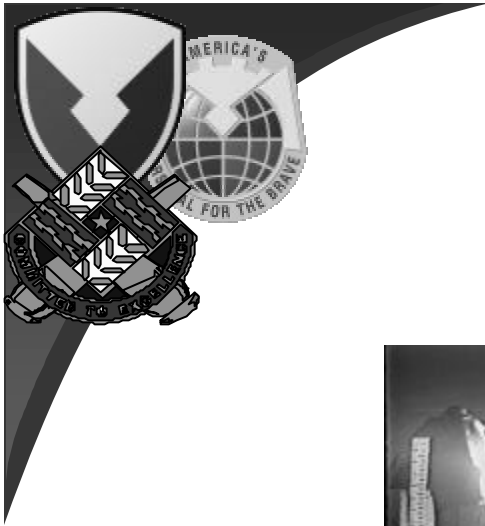
# Introduction

- Strong interest in ability to vary target effects
  - Lethal to less than lethal
  - Military, DOJ, other law enforcement agencies
  - Area denial, MOUT, MOOT, MOBA, facility protection
- Laser technology pursued over last 15 years
  - PIKL technology sponsored
  - Subject target to mechanical loading and ablation
  - Chemical lasers present problems
- Solid state laser technology promising
  - Size, weight, performance advantages
  - Peak and average powers
  - Performance parameters can be achieved

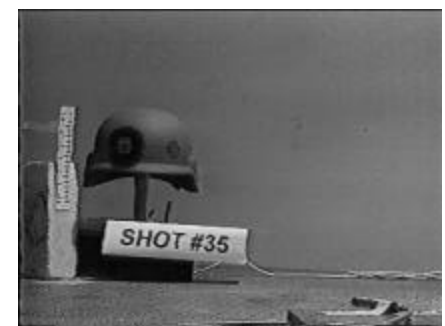
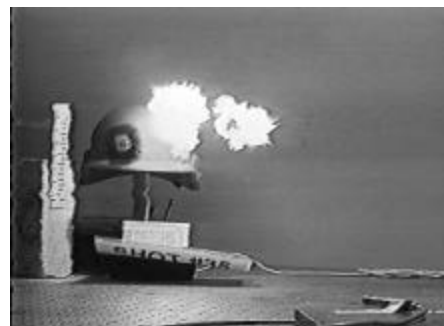
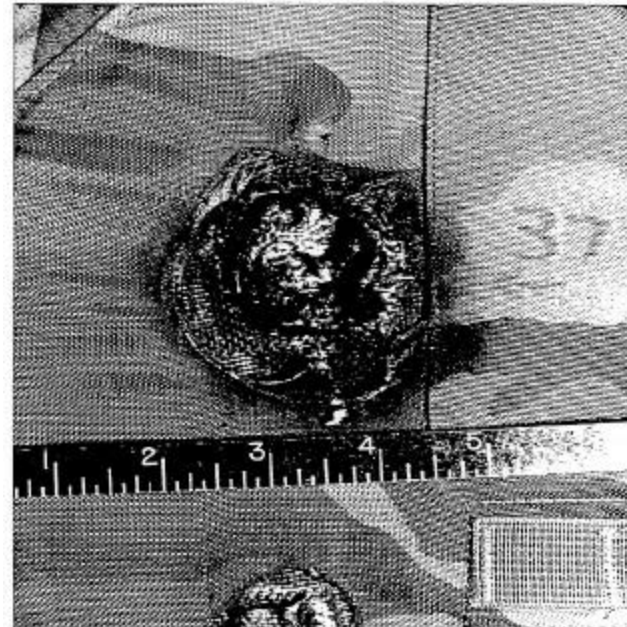


# PIKL Program Overview

- Pulsed impulsive kill laser (PIKL)
  - Target interaction: ablation and mechanical impulse
  - Pulse ‘trains’ can literally chew through target material
    - No burning
  - Effect is independent of:
    - Laser type
    - Target type



# PIKL Effects





# PIKL Program

## Prototype Development

- Chemical laser chosen to meet energy per pulse and system portability goals
- DF laser chosen for excellent transmissivity especially over longer distances desired (1-2km)
- UV initiation chosen to improve efficiency and reliability



# PIKL Prototype Development

- High energy prototype used to study laser pulse effects
  - Photographic paper, wet chamois (skin simulant), BDU material, Kevlar vest material
  - Quantifying target effect required measuring impulse delivered to target
  - Impulse transducer system designed to measure effects

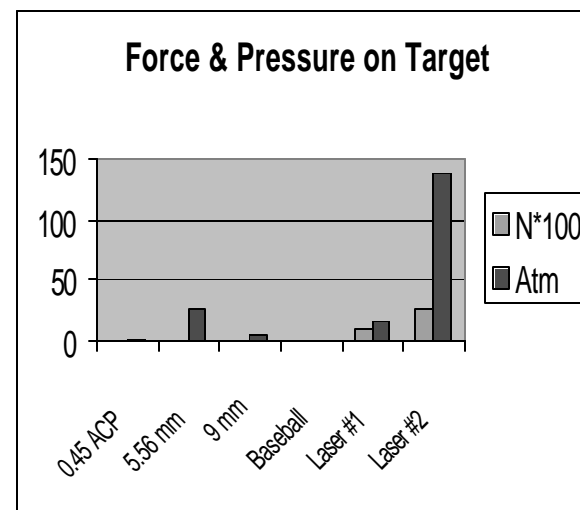
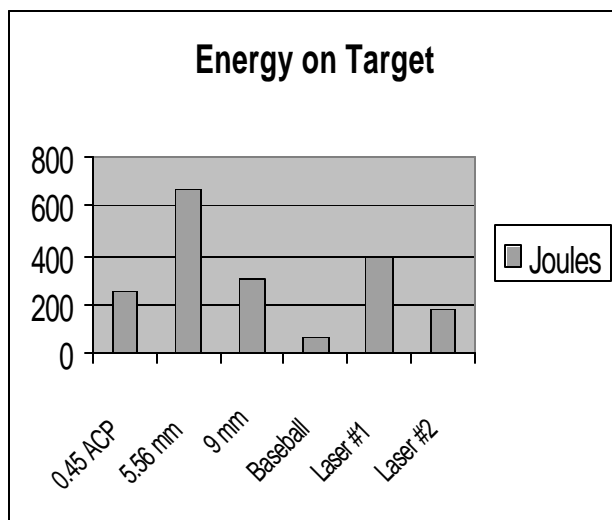




# Comparison of Impact Parameters for Various Systems



Summary	Units	0.45 ACP	5.56 mm	9 mm	Baseball	Laser #1	Laser #2
Energy on Target	Joules	249.75	663.59	305.40	58.79	400.00	179.00
Momentum at Target	N*s	2.73	2.18	2.23	4.29	0.03	0.01
Specific Impulse at Target	Kilotap	265.01	864.01	348.68	6.74	0.53	0.69
Interaction Time	msec	109.36	32.81	72.91	50.00	0.03	0.01
Force on Target	N	24.98	66.36	30.54	85.73	1000.00	2756.60
Pressure on Target	Atm	2.42	26.34	4.78	0.13	16.67	137.10





# PIKL Program

## Armstrong Labs Bio-effects Analysis

- Conclusions
  - Impulses and pressures developed were two orders of magnitude below those needed to produce serious injuries with single pulses
  - Detonative coupling does not appear to produce greater probability of damage than ablative coupling
  - Surface damage can be significant with ablative

Multiple pulse trains produced moderate to severe damage



# Solid State Lasers

- Solid state (SS) laser technology is advancing rapidly
- SS lasers offer many advantages to future weaponization concepts:
  - Smaller size
  - Lower weight
  - Ease of use/handling (no hazardous chemicals)
  - Frequency agility through dye doping



# Solid State Lasers Technology Advancements



- Diode-pumping
  - Higher electrical efficiency than flash pumping
  - Higher reliability and lifetimes
  - Smaller weight/volume
  - More rugged
  - Less waste heat
- Slab lasers
  - High optical performance
  - Minimal performance degradation due to thermal effects
  - Easier removal of waste heat
  - Reduced optical distortions
- Dye-doped SS laser rods
  - Frequency agility without dangerous liquid solvents
  - Ease of use with solid state host
  - Operation in three pump modes: CW, mode-locked, and pulsed
    - Outputs can be varied



# PIKL Technology Operational Benefits

- PIKL is a “feeder” technology into the Agile Target Effects (ATE) STO and Future Combat System (FCS)
  - ATE STO addresses AAN short list for Future Fighting Ground Vehicle
  - Developing brassboard weapons capable of lethal tunable target effects
  - Demonstrate utility of Directed Energy Weapons (DEW) against personnel and materiel targets
- Leveraging with SMDC and National Labs and their SS laser technology



# PIKL Technology Operational Benefits

- Applying PIKL technology for FCS:
  - Anti-materiel effects:
    - Disrobing explosive armor
    - “Blunt Trauma”
    - Anti-UAV
  - Anti-personnel effects:
    - “Blunt Trauma”
    - Suppression
- Rapidly project Tunable Target Effects to ranges of 2 km



# PIKL Technology Operational Benefits

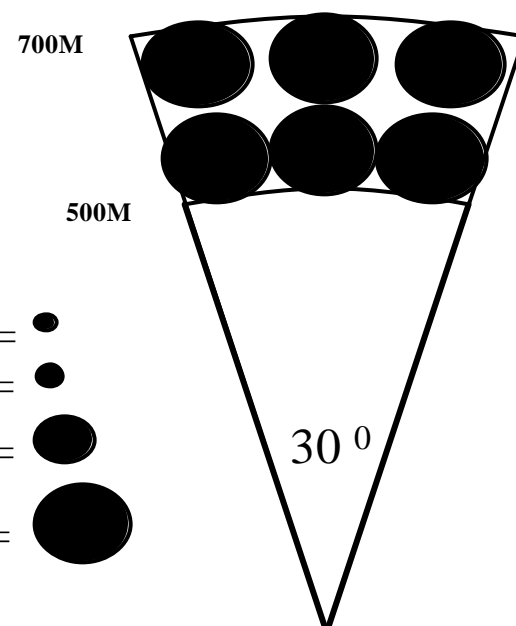
- Application of PIKL technology
  - Area Denial
  - Crowd Control
  - Facility Protection
  - Suppression
  - Military Operation Other than War
  - Military Operation on Urban Terrain
  - Law Enforcement



# PIKL Firing Scenario - Suppression

- ▲ Assumed source: 173 dB (13,000 Pascals)
- ▲ Area for suppression: zone covering 30° at a range of 500 to 700 meters (approx. 63,000<sup>2</sup>m )
- ▲ Fire 6 shots over 1 minute
- ▲ Attenuation analysis shows that a 173 dB source will attenuate to 130 dB at a distance of 50 meters
- ▲ Attenuation with range:

150 dB at 10m	dia =	●
145 dB at 20m	dia =	●
136 dB at 50m	dia =	●
130 dB at 100m	dia =	●







# Summary

- Technologies such as PIKL that can provide varying target effects (lethal and less than lethal) have a broad area of interest
- PIKL technology has made significant progress over the past 15 years
- Solid state lasers have also made significant strides
- Combining SS laser technology and the PIKL concept can produce systems with the necessary parameters required for military utility